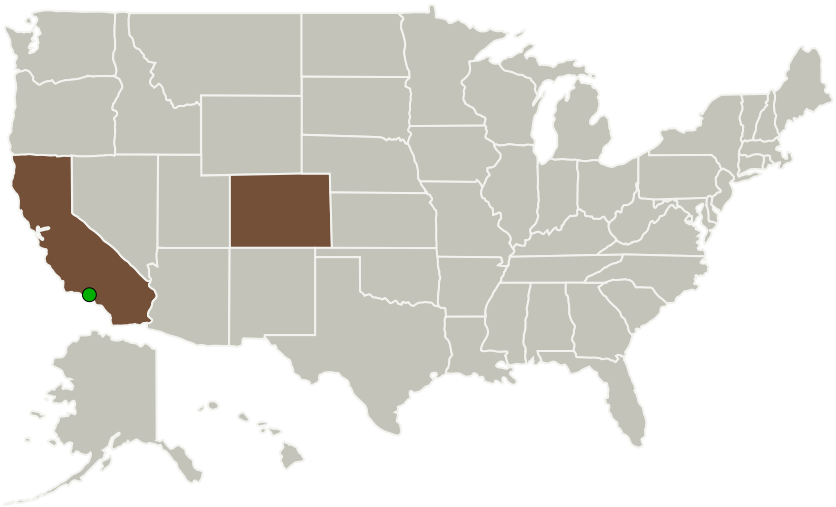
Extraterrestrial Metals Processing, Phase I

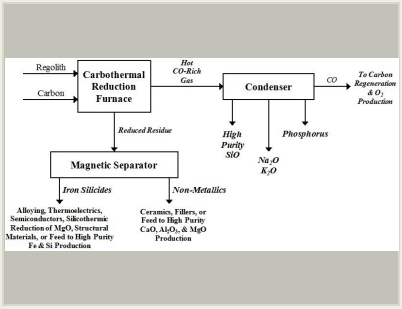
Completed Technology Project (2016 - 2016)

Project Introduction

The Extraterrestrial Metals Processing (EMP) system produces ferrosilicon, silicon monoxide, a glassy mixed oxide slag, and smaller amounts of alkali earth compounds, phosphorus, sulfur, and halogens from Mars, Moon, and asteroid regolith by carbothermal reduction. These materials, in some cases after further processing with other in-situ resources, are used for production of high-purity iron and magnesium metals (for structural applications), high purity silicon (for photovoltaics and semiconductors), high purity silica (for clear glass), refractory ceramics (for insulation, thermal processing consumables, and construction materials), and fertilizer (from phosphorus recovered from carbothermal reduction exhaust gases). Carbothermal reduction also co-produces oxygen at yields on the order of 20 percent of regolith feed mass when integrating downstream processes to recover and recycle carbon. Many of the EMP products can be prepared in a fashion suitable for casting or additive manufacture methods and have broad application in support of advanced human space exploration. The EMP methods are based on minimal reliance on Earth-based consumables; nearly all of the gases and reagents required for processing can be manufactured from Mars in-situ resources or can be recovered and recycled for applications using Moon or asteroid resources.

Primary U.S. Work Locations and Key Partners





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Organizations Performing Work	Role	Type	Location
Pioneer Astronautics	Lead Organization	Industry Historically Underutilized Business Zones (HUBZones)	Lakewood, Colorado
Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations	
California	Colorado

Project Transitions

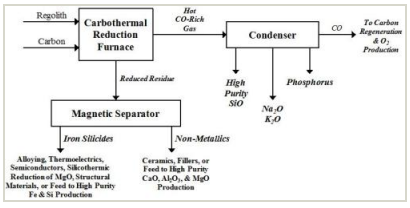
June 2016: Project Start

December 2016: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/139911)*

Images



Briefing Chart Image
Extraterrestrial Metals Processing, Phase I
(https://techport.nasa.gov/image/136382)

Final Summary Chart Image
Extraterrestrial Metals Processing, Phase I Project Image
(https://techport.nasa.gov/image/128207)

Organizational Responsibility

Responsible Mission Directorate:
Space Technology Mission Directorate (STMD)

Lead Organization:
Pioneer Astronautics

Responsible Program:
Small Business Innovation Research/Small Business Tech Transfer

Project Management

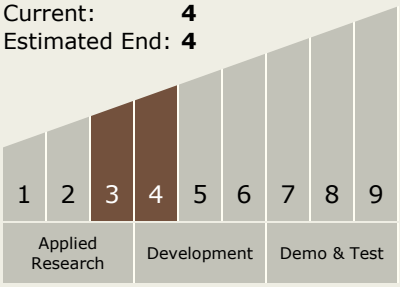
Program Director:
Jason L Kessler

Program Manager:
Carlos Torrez

Principal Investigator:
Mark Berggren

Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**



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Technology Areas

Primary:

- TX07 Exploration Destination Systems
  - TX07.1 In-Situ Resource Utilization
    - TX07.1.4 Resource Processing for Production of Manufacturing, Construction, and Energy Storage Feedstock Materials

Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System